We thank the reviewer for their comments and present our responses here in blue text

Soil Physics is fundamentally important

We agree completely that accurate representation of soil physics processes in land surface models is absolutely crucial. When using a land surface model, there is inevitable uncertainty in the soil texture. Textures taken from any global dataset, as in this study, are likely inappropriately coarse. On the other hand, soil texture measurement taken at a point may also be unrepresentative of the scales on which land surface models are run. The usual approach is to use a pedotransfer function that has been optimised on very small scale measurements; here we are trialling the opposite approach and show that we can produce a consistent improvement to soil moisture outputs without generating completely unphysical soil physics parameters.

Great thanks to the authors for their efforts in addressing the comment. On the other hand, this reviewer is not convinced with the response by only adding "we assume that the soil texture values from the HWSD are correct …" while without evolving the fundamental view in terms of soil physics. This reviewer will motivate his observation with the following main point:

In the previous comment, this reviewer mentioned that "…This actually means that the better match between predicted SM and the COSMOSUK SM measurement, as demonstrated in this study, can be achieved with any other soil texture information input (e.g., SoilGrids, or FAO-UNESCO). But then, this is very dangerous then, as it will lead to speculation that the in-situ measured soil information is not important…"

We agree that using in-situ soil texture measurements would have been better. Unfortunately we do not have access to this data at the sites we used. In addition, we wanted to investigate the possibility of using a global soil texture dataset so that our newly parameterised pedotransfer function (PTF) could then be applied anywhere.

The main reason behind the above comment is that although the current study showed very promising results in terms of improved soil moisture estimates, it was, however, achieved via optimizing constants in the underlying PTF functions.

Such an approach seems to overlook the fundamental importance of soil physics. The point is the improved performance of LSM is most probably not due to the realistic representation of soil physics, but might be potentially like 'getting results right for wrong reasons.' Unless the author can prove this point, this reviewer will suggest the authors continue their efforts in taking soil physics into account. For example, the PTF parameters (constants), being the focus of this study, are not soil physical property that can be measured directly, the optimization of which means no specific contributions to the understanding of soil physical processes. Perhaps, a better target for doing this exercise is to estimate directly the soil texture, which can be easily obtained either from the field or the soil database.

We agree that there is danger here of getting the right answer for the wrong reason. However, we would argue that our results are robust for the following reasons:

We have optimised a pedotransfer function taking into account soil texture and COSMOS-UK measurements from 16 independent sites simultaneously. We do not optimise the PTF on a per site basis. The fact that one newly optimised PTF improves the fit to data across all 16 sites suggests that

this is a systematic improvement to the PTF –i.e. to the mapping between soil texture as reported in the HWSD and the soil physics parameters.

The new soil physics parameters which are obtained with the newly optimised PTF are within the range of physically reasonable values. We did not constrain these values in any way so it would have been possible to generate physically unrealistic values; in this case we would have shared the reviewer's concern about getting a better match to soil moisture measurements for spurious reasons.

As an extra test, we re-ran our experiment using soil texture information from SoilGrids. We found that the textures were indeed substantially different than those in the HWSD at some of our locations. However, we found that our conclusions were broadly consistent no matter which soil texture database we used. In both cases we were able to show a better fit to soil moisture data at all sites after optimising our chosen ptf, as shown in fig.1. We again found that the largest contribution to this improvement was in the alpha component of the KGE metric, i.e. we increased the range of soil moisture values available to JULES. We also again found that the value of vsat increased at all sites, and that the values of Ksat and sathh decreased across all sites after data assimilation; see fig.2.

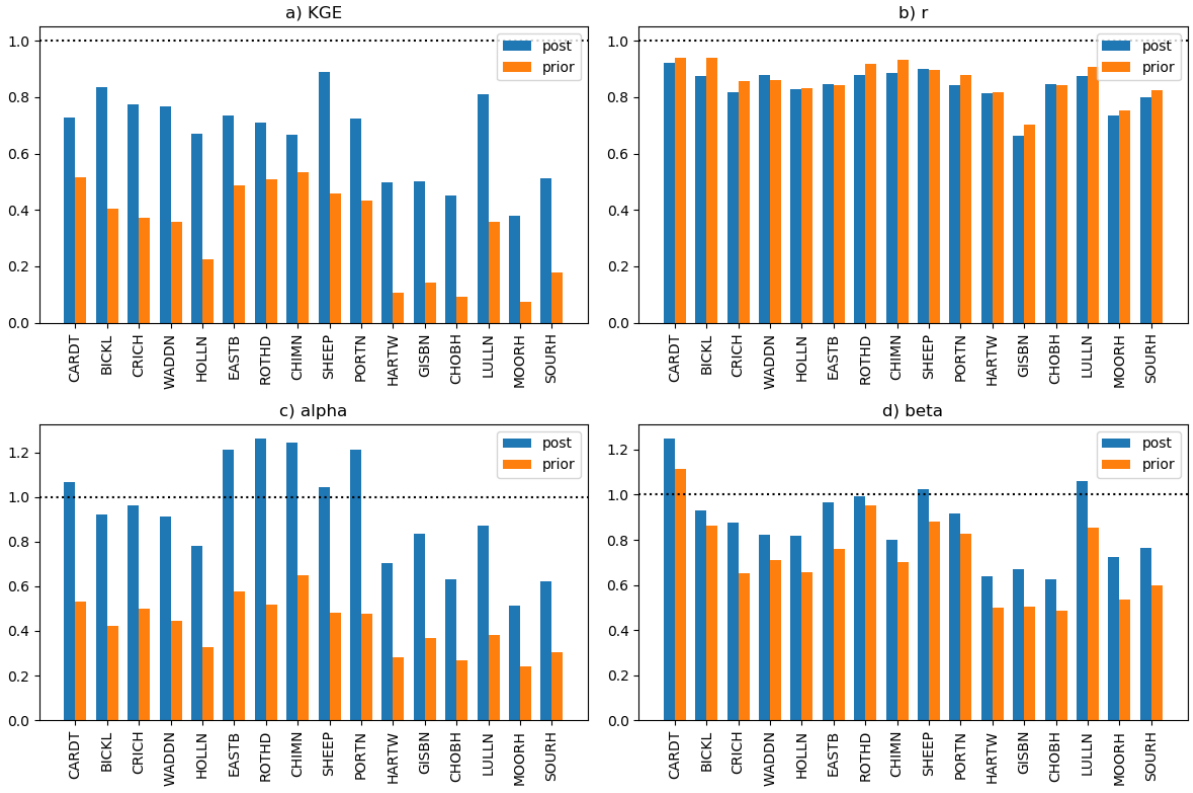

Figure 1: KGE metrics using SOILGRIDS soil texture database

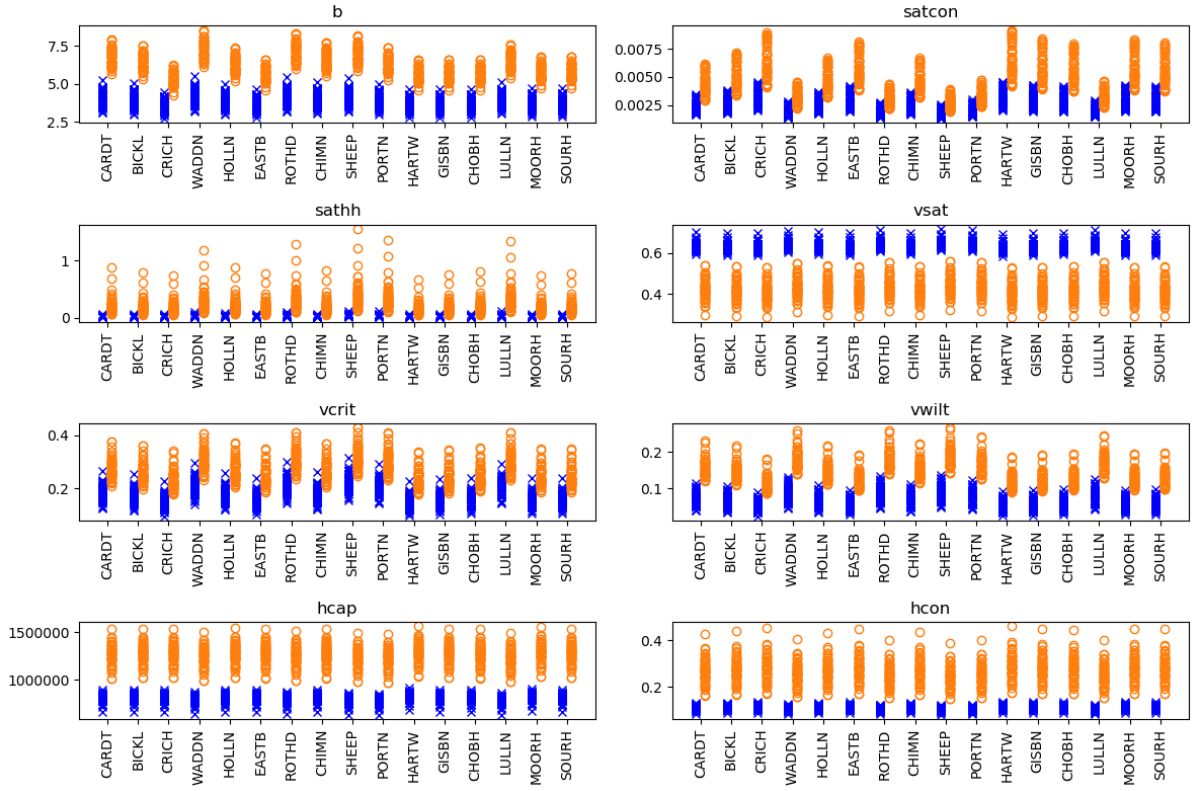

Figure 2: Prior and posterior soil physics parameters using SOILGRIDS.

The authors note that it would be interesting to compare and contrast the results from the two different soil texture databases, but feel that this analysis is not within the scope of this paper.

Some minor points as below for the author's further considerations:
1. In case the author want to pursue further their original direction, this reviewer would suggest them to have a look at the impact of applying different soil databases on their findings;

Please see our response to the comment above.

2. Instead of using only one PTF, this reviewer would suggest the author consider comprehensively other PTFs as well;

We present a method which could be applied to any combination of soil database and PTF.

3. No matter which above point was considered in the further revision, this author would like to see the comparison between the estimated soil hydraulic (and thermal if possible/feasible) properties with either in-situ or lab measurements (e.g., soil water retention curve, hydraulic conductivity curve, etc.).

As we stated in our response to the first round of comments, unfortunately we just don't have this data. However, as suggested by the reviewer, we have applied our method to soil texture information from the SoilGrids database and found our conclusions still held, strengthening our hypothesis that it is possible to optimise PTFs on observations from larger scales.

4. furthermore, perhaps the author can also clarify: instead of updating soil texture with the LaVEnDAR system, which only has two variables (e.g., sand and clay) to be updated, the 12 PTFs

constants were targeted. Would not be more computationally effective to update 2 instead of 12? Or perhaps this reviewer missing something here.

This is an approach we considered. However, given that we has no in-situ data to compare to, we felt that updating soil texture was probably not particularly useful in this case. We also wanted to have an approach which we could apply at any geographical location, and using a global soil texture database in conjunction with optimising a pedotransfter function meant that this was possible.

We propose to amend and add text to the paper to clarify our position that soil texture and soil physics processes are fundamentally important, and to mention the consistency of our results when using a different soil texture database.

Line 287:

Representation of soil physics processes in LSMs is fundamentally important in modelling soil moisture. The improvements in soil moisture seen here were obtained by assimilating all the soil moisture values across 16 sites simultaneously rather than on a per site basis. This strengthens our implicit assumption that the same physical processes can be modelled (through JULES and the Cosby pedotransfer function) for a range of different UK sites and soil types.

Line 300:

We acknowledge that our optimisation of the Cosby PTF here relies on consistent soil texture data from the HWSD. In order to strengthen our conclusions we therefore repeated our experiment using the SoilGrids soil texture database (Hengl et al, 2017). This gave similar results to the ones shown; optimising the Cosby PTF produced a better match to the observations at all sites and we saw a resultant increase in θ_{sat} (vsat) and reduction in both K_{sat} (satcon) and ψ_{sat}(sathh).